THE EFFECT OF AN 18-WEEK DETRAINING PERIOD ON BODY COMPOSITION AND CARDIORESPIRATORY ENDURANCE IN A COHORT OF ARMY ROTC CADETS

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INTRODUCTION

Multiple studies have reported the detrimental relationship between poor cardiorespiratory endurance and above average percent body fat (%BF) on the Reserved Officers' Training Corps (ROTC) cadet's physical fitness performance. [1-4] The ROTC program is a collegiate officer-training program, with participants who will serve in the United States Armed Forces after graduation. [1, 5] In addition to basic military training, Army ROTC cadets participate in a training program similar to the U.S. Army's physical readiness training (PRT) program. The PRT was designed to build strength, stamina, agility, resiliency and coordination throughout the academic year. [6]

Physiological adaptations, associated with chronic physical training, develop within the first 12 weeks of ROTC physical training [5, 7] and play a key role in cadets' physical readiness. Maintenance of these adaptations requires consistent participation in PT, however mandatory ROTC cadet PT is interrupted by the long-term summer break associated with the university's academic calendar. Liguori et al. previously reported decreases in maximal oxygen uptake following a 13-week summer break without mandatory PT in ROTC cadets. [1] To our knowledge this was the only study looking at the affects of a summer break on VO_{2max} on ROTC cadets. During the summer break the cadets are encouraged to continue self-directed training; however, as demonstrated by Liguori et al, the lack of mandatory instructed PT may negatively affect the cadet's physical readiness. What is unclear, is whether the lack of mandatory PT would make the decrease in aerobic fitness a universal finding or if encouragement to continue the PT on their own during the summer break would allow some groups of ROTC cadets to maintain fitness during this time period.

Cessation in PT may affect both muscular and cardiorespiratory endurance, which in turn may affect physical readiness. Previous research reports a decrease in maximal oxygen consumption (VO_{2max}) in trained athletes after a short-term [8-12] and long-term [1, 13, 14] training cessation. Significant declines in VO_{2max} were reported in collegiate tennis players[8], collegiate swimmers[9], and professional soccer players [11] after a short term (4-6 week training cessation). Changes in body composition after a period of detraining have also been investigated. There is a general agreement within the literature that detraining results in an increase percent body fat (%BF) [8, 9, 11, 13] and increases in body circumference measurements [9]. Body composition was not addressed in the study by Liguori et al, therefore it remains unclear how the cessation of mandatory PT over the summer break many affect ROTC cadets.

Physical readiness is determined by physical fitness standards defined in the Army Physical Fitness Test (APFT). The biannual APFT provides an assessment of muscular and cardiorespiratory endurance via the 2-minute timed push-up, 2-minute timed sit-up and a 2-mile timed run. Cadets participate in physical training (PT) at least three times a week during the academic year to develop the physical rigor needed to complete the APFT.[6] Unfortunately, the fall APFT is given nearly a month after mandatory PT has been restarted from returning from summer break. This obviates the use APFT as an index to determine changes in fitness due to the delay in testing following the summer break.

During the academic summer break, high-ranking level ROTC cadets are dispatched to Advance Training Camps (ATC) for a 5-week rotation in which they undergo advanced military operation training. Although the cadets do partake in minor physical training exercise, there is an apparent disruption from the cadets mandatory PT guided by the ROTC officers.

Currently, limited research exists on the effect of the long-term training cessation on VO_{2max} and body composition in ROTC cadets.[1] Therefore, the purpose of the study is to determine the effect of the summer cessation in mandatory PT on cardiorespiratory endurance and body composition measurements on the Army ROTC cadets.

METHODS

Research Design

A repeated measures design was conducted consisting of two data collection sessions to determine the effect of an 18-week cessation in physical training body composition measurements, cardiorespiratory endurance, and APFT performance. The pre-test (spring) data collection was completed at the end of the academic year, less than two weeks from the cadets' completion of the spring APFT. The post-test (fall) data collection was administered at the beginning of the new academic year, two-weeks after the subjects returned to campus. The cadets completed the fall APFT three months after returning to mandatory physical training. Independent variables included gender and length of detraining. Dependent variables included APFT scores (2-minute push-up test, 2-minute sit-up test, and 2-mile timed run), VO_{2max} values, and body composition measurements.

Subjects

A total of 46 Army ROTC cadets were recruited from the University of Hawaiʻi at Mānoa Army ROTC Warrior Battalion. Twenty-six male and nine female cadets (age= 22.54 ± 3.42 years) participated in both of the testing sessions. Seven subjects had suffered a lower body injury during the summer break and 4 subjects did not continue on in the ROTC program. Inclusionary criteria included classification as low-risk according to the American College of Sports Medicine (ACSM) guidelines for exercise testing. Exclusionary criteria include lower body injury, dropping out of the ROTC program or current or suspected pregnancy.

Instruments

The APFT was conducted in accordance with military protocol and was used to determine cardiorespiratory and muscular endurance. A wall-mounted stadiometer (Model

67032, Seca Telescopic Stadiometer, Technology, Inc., Gays Mils, WI, USA) was used to record stature. A Detecto Certifier Scale model 442 (Detecto, Webb City, MO) was used to measure body mass (BM). Lange Skinfold Calipers (Cambridge Scientific Industries, Inc., Cambridge, Maryland, USA) were utilized to obtain skinfold thickness (SKF) measurements. Jackson and Pollock's male and female three skinfold site (SKF) protocols were utilized to measure SKF thickness. [15, 16] A Gulick standardized tape measure was utilized for body circumference measurements.

A modified Åstrand treadmill protocol was used to determine VO_{2max}. [22] The modified Åstrand treadmill protocol was conducted on a Star Trac Treadmill (Unisen, Inc., Irvine, CA), which was calibrated per the manufacturer's instructions prior to the start of the study. A Parvo metabolic cart (Parvo Medics, USA) calibrated per the manufacturer's instructions and ParvoMedics TrueOne Metabolic software were used to obtain metabolic and physiological data in order to determine maximum oxygen consumption. A two-way non-rebreather valve system and tube (Hans Rudolph) was used to collect oxygen and carbon dioxide during ventilation. Vantage Vue (Davis Instruments, Hayward, CA.) was used to gather room temperature (Celsius), barometric pressure (mmhg), and relative humidity. A Polar Pacer T31 heart rate (HR) monitor (Polar Electro, Finland) was used to record heart rate at each stage of the graded exercise test (GXT). Sprague stethoscope (model number 641, Diagnostix, Hauppage, NY) and an aneroid sphygmomanometer (model number 700, Diagnostix, Hauppage, NY) blood pressure cuff were utilized to measure blood pressure. During the modified Åstrand treadmill protocol, perceived exertion was measured utilizing Borg's 15-point Ratings of Perceived Exertion (RPE) scale. [23] A Lactate Plus Analyzer (Nova Biomedical Corporation, Waltham, Massachusetts, USA), calibrated per the manufacturer's instructions, was used to obtain blood lactate concentrations pre- and post- VO_{2max} testing.

Procedures

The APFT was administered at the end of the spring semester and three months after returning to mandatory physical training for fall semester. The tests were completed under supervision of the Army ROTC Battalions' commanding officers and scored in accordance to the PRT manual. [6]

The Anthropometric data and VO_{2max} tests were collected two separate 1½-hour test sessions at the University of Hawaiʻi at Mānoa Human Performance Laboratory. The spring testing session was completed within two-weeks following the spring APFT and the fall testing session was completed within two-weeks of returning back from summer break.

Subjects were given standardized written and verbal instructions prior to initiation of all test sessions. All subjects gave informed consent, and completed a health history questionnaire, the Physical Activity Readiness Questionnaire (PAR-Q) and Physical Fitness Questionnaire (PFQ) adapted from George et al. [17] to self-identify physical fitness. The PFQ has three questions which asks the subject to predict their current running times for one-mile and three-mile distance and lastly to rate their current level of overall fitness over the past six-months. All forms were reviewed and approved by a member of the research team before entry to the study.

Following form completion, resting heart rate was taken by palpating the radial pulse. A blood pressure measurement was taken two different times in order to obtain an average resting blood pressure reading. Anthropometric measurements including height and body mass were measured. Body mass index (BMI) was calculated from body mass and height. Body circumference measurements were obtained in accordance to the Army Body Composition

Program’s measurement guidelines. [18] Male circumference measurements included the neck, abdomen, knee and umbilicus. Female circumference measurements included the neck, waist (narrowest point between the xiphoid process and iliac crest), umbilicus, and hip. [15, 16] All SKF measurements was assessed on the right side of the body at three skinfold sites which consisted of the triceps, supra-ilium, and thigh for female subjects and the chest, abdomen, and thigh for male subjects. Skinfold thickness measurement was assessed in an alternating pattern to allow restoration of tissue elasticity. An average of two SKF measurements for each site were used for analysis. A third SKF measurement was obtained if measured SKF values differed by 1 or more millimeters, and all three SKF measurements were averaged. [15, 16]

A HR monitor was dampened and tightly fitted to the bare skin over the xiphoid process. Blood was taken via the finger-prick method to determine pre-test blood lactate concentrations. Each subject was given verbal explanation of the Borg’s RPE scale and the multi-stage modified Åstrand protocol. Determination of running pace was conducted prior to the start of the graded exercise test (GXT), with subjects unaware of the treadmill speed chosen for the test. Subjects completed voluntary, self-directed stretching and a five-minute brisk walk (off treadmill) prior to starting the GXT. The subjects were fitted with headgear, mouthpiece, and nose clip, after which then began the GXT. Each subject was provided 2-3 minutes on the treadmill for familiarization. The first 3-minute stage of the GXT was conducted at the predetermined speed (mph) and at a 0% grade. Incremental increases in percent grade continued every 2-minutes for the duration of the GXT. Ratings of perceived exertion (RPE), HR, respiratory exchange ratio (RER), and VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$) were recorded at the end of every stage of the GXT. Verbal encouragement was provided to each subject for the duration of the GXT. The test was terminated at volitional exhaustion. Immediately following termination of the GXT, subjects completed a two-minute active cool-down at a speed of 1.0-2.0 mph and a grade of 0%. Seven minutes after completion of the GXT, post-test blood lactate concentration was measured. Determination of maximal effort was based on guidelines for maximal exertion, including RPE >17, > 8mmol blood lactate concentration, a plateau in oxygen consumption, a RER of >1.10 and a failure of HR to increase with increased exercise intensity. [19]

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Services (SPSS) version 23 with an alpha level set at $p<0.05$. Multiple one-way repeated measures analysis of variance (ANOVA) was used for comparisons of APFT scores, VO_{2max} values, and body composition variables over time. T-tests were used to determine if significant differences existed for body composition data including skinfold and circumference measurements.

RESULTS

Male and female participants had a significant increase in body mass (Δ=-1.1 kg, *p*=0.0153; Δ=1.21 kg, *p*=0.004; respectively), shown in Table 1. Body Mass Index (BMI) was significantly increased in male (Δ=0.35 kg/m^2, *p=0.0185*) and females cadets (Δ=0.4 kg/m^2, *p=0.0178*). Body fat percentage (%BF) was significantly increased in males (Δ=1.9%, *p=0.0001*) however not found significantly different in female (Δ=1.07%, *p*=0.11) cadets. Army estimated %BF did show a significant change in both male (Δ=1.5%, *p*=0.006) and female (Δ=1.21%, *p=0.021*) cadets between the testing sessions.

Skinfold and circumference measurements reflect significant increases in both male and female cadets (Table 2 and 3). Female thigh and triceps skinfold measurement elicited significant increases (Δ=3.0 mm, *p*=0.015; Δ=1.32 mm, *p*= 0.041, respectively). No significant difference was reflected in the sum of skinfold measurements of female cadets from spring (Δ=3.57 mm, *p*=0.055) to fall testing sessions. Significant differences are found in male chest (Δ=1.97 mm, *p*=0.0001), thigh (Δ=0.97 mm, *p*= 0.04) and abdominal (Δ=3.88 mm, *p*=0.00005) skinfold measurement between testing sessions. A significant increase was found in the sum of skinfold measurement in male cadets between the testing sessions (Δ=6.82 mm, *p*=0.00001). Female hip circumference is significantly increased (Δ=1.97 cm, *p*=0.035). A significant increase was found in the sum of circumference measurements in female cadets from spring (Δ=3.60 cm, *p*=0.047) to fall testing sessions. Male cadets displayed significant increases in iliac crest (Δ=1.97 cm, *p*=0.001) and umbilicus circumference (Δ=2.46 cm, *p*=0.00002). A significant increase was revealed in the sum of circumference in male cadets following the summer cessation (Δ=5.00 cm, *p*=0.00005).

Table 1: Cadet Spring vs. Fall Demographics

	Male								Female							
	Spring			n=26	Fall				Spring			n=9	Fall			
	Mean	±	SD		Mean	±	SD	*p*	Mean	±	SD		Mean	±	SD	*p*
Age (Years)	22.92	±	3.81		23.19	±	4.03	0.008*	21.44	±	1.59		21.67	±	1.58	0.084*
Body mass (kg)	76.59	±	9.71		77.80	±	9.11	0.015*	63.01	±	5.46		64.16	±	5.70	0.0044*
Height (cm)	175.18	±	5.95		175.06	±	5.92	0.140	162.73	±	5.69		162.59	±	5.97	0.28
BMI (kg/m^2)	24.95	±	2.70		25.30	±	2.48	0.018*	23.70	±	1.59		24.27	±	1.92	0.0178*
%BF (%)	12.47	±	3.80		14.36	±	3.34	0.0001*	23.50	±	1.53		24.57	±	1.41	0.113
Army %BF (%)	15.41	±	5.06		16.91	±	4.67	0.006*	28.60	±	3.36		29.81	±	3.85	0.021*

BMI: Body Mass Index; %BF: percent body fat calculated from skinfold thinkness and Brozak equation; Army %BF calculated by circumference measurement equation ,*indicates p<0.05

Table 2:Female Spring vs. Fall Skinfold Thickness and Circumference Measurements

	Spring n=9			Fall n=9				
	Mean	±	SD	Mean	±	SD	T-Statistic	*p*
Suprailiac Skinfold (mm)	22.64	±	3.44	21.89	±	3.34	0.41	0.35
Tricep Skinfold (mm)	18.71	±	2.46	20.03	±	2.71	-1.98	0.04*
Thigh Skinfold (mm)	20.20	±	2.68	23.20	±	2.68	-2.59	0.01*
Sum of Skinfold (mm)	61.55	±	5.12	65.12	±	4.89	-1.76	0.06
Neck Circumference (cm)	33.98	±	1.20	34.17	±	1.28	-1.11	0.15
Waist Circumference (cm)	75.33	±	3.83	75.86	±	4.49	-1.03	0.17
Hip Circumference (cm)	97.33	±	4.53	99.31	±	3.91	-2.10	0.03*
Iliac crest Circumference (cm)	83.05	±	4.93	83.94	±	5.21	-0.95	0.18
Sum of Circumference (cm)	289.70	±	12.24	293.30	±	13.12	-1.89	0.04*

*indicates $p<0.05$.

Table 3: Male Spring vs. Fall Skinfold Thickness and Circumference Measurements

	Spring n=26			Fall n=26				
	Mean	±	SD	Mean	±	SD	T-Statistic	*p*
Chest Skinfold (mm)	11.01	±	3.73	12.98	±	3.84	-4.22	0.0001*
Abdominal Skinfold (mm)	16.71	±	6.33	20.59	±	4.98	-4.61	0.00005*
Thigh Skinfold (mm)	15.29	±	5.43	16.26	±	4.55	-1.82	0.04*
Sum of Skinfold (mm)	43.00	±	13.33	49.82	±	11.82	-5.08	0.00001*
Neck Circumfence (cm)	38.22	±	2.94	38.94	±	1.47	-1.43	0.08
Umbillicus Circumference (cm)	83.73	±	7.08	86.19	±	6.93	-4.83	0.00002*
Iliac Crest Circumference (cm)	84.25	±	6.86	86.04	±	6.89	-3.39	0.001*
Sum of Circumference (cm)	206.2	±	15.05	211.20	±	14.70	-4.55	0.00005*

*indicates $p<0.05$.

Table 4: Cadet Spring vs. Fall Metabolic Output

	Male n=26			Female n=9		
	Spring	Fall		Spring	Fall	
	Mean ± SD	Mean ± SD	*p*	Mean ± SD	Mean ± SD	*p*
Relative VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	51.12 ± 4.15	49.38 ± 3.27	0.004*	42.36 ± 3.47	41.11 ± 3.86	0.084
Absolute VO_{2max} ($L \cdot min$)	3.92 ± 0.55	3.84 ± 0.49	0.093	2.68 ± 0.30	2.63 ± 0.26	0.352
Time on Treadmill (min:sec)	11:18 ± 1.60	11:02 ± 1.55	0.003*	13:31 ± 1.27	12:12 ± 0.98	0.001*
Peak RER	1.19 ± 0.03	1.17 ± 0.04	0.098	1.17 ± 0.05	1.19 ± 0.04	0.295
Pre-BLC ($mmol \cdot L^{-1}$)	1.50 ± 0.59	1.28 ± 0.55	.0049*	1.36 ± 0.36	1.22 ± 0.36	0.232
Post-BLC ($mmol \cdot L^{-1}$)	10.60 ± 2.02	9.01 ± 2.57	0.003*	7.71 ± 2.08	9.70 ± 1.53	0.053
METS	14.50 ± 1.17	14.1 ± 0.93	0.006*	12.10 ± 0.99	11.73 ± 1.11	0.079
HRmax (bpm)	188.76 ± 7.50	184.3 ± 8.00	0.0004*	189.22 ± 5.95	187.44 ± 5.24	0.082
RPE	19.70 ± 0.42	19.4 ± 0.7	0.004*	19.22 ± 0.83	18.88 ± 0.92	0.346

Final RER: Respiratory Exchange Ratio (CO2/O2); Pre-BLC: Pre-test Blood Lactate Concentration (millimole per liter)
Post-test Blood Lactate Concentration (millimole per liter); MET: Metabolic Equivalent of Task; Max HR: Maximum Heart Rate (Beats per Minute)
RPE: Ratings of Percieved Exertion; *indcates p<0.05.

Table 4 shows significant declines in male relative VO_{2max} results (Δ= -1.74 ml•kg^{-1}•min^{-1}, p=0.004) however no significant decline in female cadets (Δ= -1.25 ml•kg^{-1}•min^{-1}, p=0.0849). No significant declines in absolute VO_{2max} were observed for either male or female participants. The data reflects no significant decrease in Respiratory Exchange Ratio (RER) for male or female cadet (Δ= -0.08, p= 0.093; Δ= -0.05, p= 0.352, respectfully). There was a significant decrease in HR_{max} with male cadets (Δ= -4.5 bpm, p=0.004) but no significant difference found in female (Δ= -1.78 bpm, p=0.082) cadets between the testing sessions. Male pre-blood lactate concentration (Pre-BLC) and post-blood lactate concentration (Post-BLC) had significant declines (Δ= -0.22 mmol, p=0.049; Δ= -1.59 mmol, p=0.003, respectfully) between testing sessions. Significant differences were found in the Physical Fitness Questionnaire males and females (Table 5).

Mean spring and fall APFT scores are shown in table 6. A significant increase was present for the two-minute timed push-up test from spring (Δ= 2.97 push-ups, p=0.019) to fall APFT testing sessions. No significant differences found for the two-minute timed sit-up test from spring (Δ= 1.57 sit-ups, p=0.147) to fall APFT testing sessions. No significant differences were found between spring (Δ= 0.07 min, p=0.256) and fall APFT results on the two-mile timed test.

Table 5: Spring vs. Fall Physical Fitness Questionnaire

	Male							Female						
	Spring	n=26		Fall				Spring	n=9		Fall			
	Mean	±	SD	Mean	±	SD	P	Mean	±	SD	Mean	±	SD	*p*
PFQ1	11.19	±	1.26	10.69	±	1.40	0.051	10.11	±	1.26	10.22	±	0.83	0.842
PFQ2	9.23	±	2.12	9.00	±	2.34	0.376	8.77	±	0.66	9.22	±	0.66	0.035*
PFQ3	7.38	±	0.8	6.80	±	1.02	0.013*	6.22	±	0.97	6.22	±	1.39	1.00

*PFQ1: Physical Fitness Question 1, George Questionnaire; PFQ2:Physical Fitness Question 2, George Questionnaire; PFQ3:Physical Fitness Question 3, George Questionnaire;*indicates p<0.05*

Table 6: Spring vs. Fall APFT Values

	Spring n=35			Fall n=35			
	Mean	±	SD	Mean	±	SD	*p*
2-minute push-up event (reps)	61.54	±	16.74	64.51	±	16.24	0.019*
2-minute sit-up event (reps)	77.60	±	9.17	79.17	±	9.62	0.147
2-mile run (min)	14.15	±	1.47	14.08	±	1.27	0.256

*indicates p<0.05.

DISCUSSION

The most important finding of this study was that the male cadets experienced a significant reduction of 3.4% in relative VO_{2max} ($ml{\bullet}kg^{-1}{\bullet}min^{-1}$) values, while the female cadets exhibited a non-significant decrease of 2.95% in relative VO_{2max}, however they were trending towards significance (p=0.08) following the summer break. Additionally, time on treadmill during the GXT decreased significantly for both genders. The male cadets decreased by a mean average of 16 seconds (p=0.003) and female cadets decreased by an mean average of 79 seconds (p=0.001). The decreases in absolute VO_{2max} (L/min) values were not significant for either gender, with the males and females showing a reduction of 2.04% and 1.86%, respectively. Although the changes in absolute VO_{2max} values failed to reach statistical significance, the decrease of VO_{2max} for the male cadets was treading towards significance (p=0.093). In contrast to the present study, a similar study by Liguori et al, involving ROTC cadets reported a significant decline of 4.2% in male and a 7.0% female relative VO_{2max}, following a 3-month summer break. Additionally, they reported a significant decline of 3.5% in male and a 7.5% female absolute VO_{2max}, following a 3-month summer break. [1] The declines of relative VO_{2max} in the present study were due to the changes in body mass and %BF. Unfortunately, Liguori et al. failed to report values for either body mass or %BF following the three month summer break.[1]

The inverse relationship between VO_{2max} results and %BF has been thoroughly recognized. [2, 3, 20] As %BF increases the decline in aerobic physical performance is evident. Crawford et al. found that soldiers who have a <18% BF performed significantly better on a VO_{2max} test then soldiers with >18% BF. In the present study only two males had a %BF of >18% reducing the effectiveness of this comparison. [2] However, Crawford et al. state that increasing %BF of >15% can have serious implications on aerobic capacity. [2] Data from the present study revealed that in the spring, 16 cadets (7 male and 9 female) with a %BF of >15% had an average VO_{2max} of 44.28 ml•kg^{-1}•min^{-1}, while the remaining 19 male cadets with a %BF of <15% had an average VO_{2max} of 52.04 ml•kg^{-1}•min^{-1}. However in the fall testing session, 22 cadets (13 male and 9 female) with a %BF of >15% had an average VO_{2max} of 45.36 ml•kg^{-1}•min^{-1}, while the remaining 13 male cadets with a %BF of <15% had a VO_{2max} of 50.44 ml•kg^{-1}•min^{-1}. Thus supporting the criterion established by Crawford et al.

Previous authors concluded that a 1% increase in %BF decreased the distance covered in the 12-minute Cooper test by 19.3m (p=0.001). [20] In contrast, Sharp et al. found no link between VO_{2max} values and %BF. In their study, two different cohorts of Army soldiers tested in 1978 and 1998 were found to have similar VO_{2max} results (50.7 ± 4.8 and 50.6 ± 6.2 ml•kg^{-1}•min^{-1}, respectively) but had a significant difference in %BF (16.2 ± 5.3% and 18.7 ± 4.8%, $p<0.05$). The non-significant change of absolute VO_{2max} suggests that cadets maintained their VO_2 but exhibited decreased results due to the increases in both body mass and %BF after the summer break.

When comparing absolute VO_{2max} values between testing sessions, 17/26 (65%) male cadets showed a decrease in absolute VO_{2max} and 6/9 (67%) female cadets decreased from spring to fall. When examining relative VO_{2max} values, 19/26 (73%) male cadets showed a decrease of relative VO_{2max} and 6/9 (67%) female cadets decreased relative VO_{2max} values from spring to fall. This indicated that only about 30% of cadets were able to maintain their fitness during the summer break.

Maintenance of the cadets training program was addressed by responses to the Physical Fitness Questionnaire. The cadets were asked to indicate a comfortable pace over a 1-mile and 3-

mile distance using a 13 point scale with a rating of 1 representing a walking pace of 18 minutes per mile and a 13 representing running a fast pace of less than a 7 minutes per mile. Male cadets reported a mean value of 11.19 in the fall and a 10.69 in the spring for the 1-mile distance. An 11 on the George form corresponds to jogging at a fast pace (8-minute mile), a score of a 10 signifies a jogging pace between medium pace (10-minute mile) and fast pace. The differences between fall and spring for the male cadets approached significance (p=0.051). There was no significant difference for the reported 3-mile pace. The cadets used an 11-point scale to indicate their overall fitness level over the past 6 months with a rating of 1 representing the avoidance of walking or exertion and a score of an 11 representing running over 25 miles per week. The male cadets reported a mean value of 7.38 (I run 5 miles to less than 10 miles per week) in the spring and a 6.80 (I run 1 mile to less than 5 miles per week) in the fall. The differences reached significance between fall and spring sessions (p=0.01). Female cadets reported no difference when rating their 1-mile pace or the overall level of fitness levels; however, they did reach significance when asked to indicate their 3-mile pace. The female cadets indicated that they could improve their 3-mile pace, by reporting a score of 8.77 in the spring and a score of 9.22 in the fall. These data support the fact that the cadets continued PT over the summer break and the differences seen in relative VO_{2max} were a result of changes in body composition.

A significant increase in body mass was present in both male (Δ=1.67%) and female (Δ=1.71%) cadets. Additionally, a significant increase of 1.89% in %BF was found in male cadets. The circumference measurements technique used by the Army did estimated a higher %BF values when compared to skinfold measurements using the Jackson and Pollock equation, however the percent differences between the testing sessions were similar (Army calculated %BF-Male: Δ=1.5%; female: Δ=1.21%; J&P calculated %BF- Male: Δ=1.89%; female:

Δ=1.07%). Body Mass Index was significantly increased by 1.6 kg/m^2 in male and 2.1 kg/m^2 in female cadets. The increases in body composition found in the current study were similar to the findings of previous detraining literature. Unfortunately, Ligouri et al. did not measure or failed to report differences in body mass, %BF, and BMI pre- and post- summer break. [1] ROTC cadets are not the only athletes affected by the lack of mandatory training during a period of training cessation. Other high level athletes experience similar physiological detriments as the result of detraining; including significant increases in body mass, %BF and BMI. [9, 11] Ormsbee et al. concluded that collegiate swimmers undergo a significant mean increase of 0.9 kg in body weight and a 2% significant mean increase in %BF following a five-week period of detraining. This occurred even though the swimmers were instructed to participant in light to moderate land based activities of < 6.0 METS during the 5-week period. [9] Furthermore, significant increases were reported in body weight and %BF in male professional soccer players following a six-week detraining period. [8] In the present study, the cessation of mandatory physical training session or an increase in caloric consumption (access to mess hall) over the summer break period appears to negatively affect the cadet's body composition even if the cadets were told to continue self-directed training.

Previous literature on cardiorespiratory endurance in a ROTC population failed to report RER values for pre- and post- testing sessions; therefore no judgment can be made whether the cadets demonstrated maximal effort during each testing sessions. [1] In this study, no significant differences were found when comparing spring and fall RER values (Table 4). This finding of similar RER values (male: Δ= -0.02; female: Δ= 0.02) demonstrates that the cadets exerted maximal effort into each of the two testing sessions. [21] Furthermore, only 1 of 70 tests did not obtain an RER of $\geq$1.10, in that particular test the cadet reached a peak RER of 1.09. This illustrates that the cadets achieved a VCO_2/VO_2 ratio of ≥1.10, which surpasses the ACSM criteria for a true VO_{2max} rather than achieving a VO_{2peak}. [19, 21]

The male cadet's HR_{max} showed a significant decline of -4.4 bpm between fall and spring testing sessions. (Table 4) A period of training cessation has previously been shown to increase both maximal and submaximal heart rate. [10, 14] However, conflicting studies have shown either increases in HR_{max} [10] or no significant change in HR_{max} over a period of training cessation. [14] Female cadets HR_{max} remained relatively unchanged between testing sessions.

Significant decreases were found with mean pre- (Δ=0.22, p=0.0049) and post- test (Δ=1.59, p=0.003) blood lactate concentration (BLC) measurements in male cadets. The male cadets achieved post- test value of ≥ 8.0 mmol in both the spring and fall that exceeded the ASCM criteria for of a true VO_{2max} test. Despite having exceeded the RER criteria for a true VO_{2max} test, the mean BLC female cadets for the spring was 7.71mmol with was slightly below the criterion. However, in the fall the mean value for female cadets was 9.70 mmol, which does meet the criterion.

The male and female cadets achieved a mean ratings of perceived exertion (RPE) above 18 for both spring and fall testing session. These values did meet the ACSM criterion for achieving a true VO_{2max} test. Significant decreases in were observed in male cadets (Δ=-0.30, p=0.0043) between testing sessions. The cadet's self-reported RPE grand mean values were 19.6 in the spring and 19.2 in the fall. These results suggest that the cadet's psychologically believed they were exerting maximal effort during the testing. Theses current findings for HR_{max}, RER values, RPE values, and pre- and post- blood lactate concentration measurements confirm that male and female cadets performed to the achieved a true VO_{2max} test for both sessions.

LIMITATIONS

A limitation to the present study was that the cadets were not required to maintain an activity log during the summer break. However, the males achieved VO_{2max} scores that placed them in the excellent fitness category according ACSM normative data and female cadets achieved superior fitness scores in both the spring and fall.

SUMMARY AND CONCLUSIONS

In summary, the Army sets forth very stringent physical standards that the ROTC cadets must achieve in order to stay within the program and to pass the Army Physical Fitness Test. However, Liguori et al, reported a decrease in VO_{2max} values for ROTC cadets as a result of the summer break. In this study, the male cadets showed a significant decrease in relative VO_{2max} performance. The cadets skinfold and circumference measurements indicated significant increases following the summer break. It was concluded that increases in cadet body mass, %BF and BMI account for decreases in relative VO_{2max} values, as absolute values were not significantly different. Finally, although changes in fitness did occur, the changes were small were deemed unlikely to effect the overall fitness of the corps because there was no change in fitness classification in either male or female cadets between the spring and fall testing session.

LITERATURE REVIEW

Reserved officers training corps (ROTC) programs are present on college and university campuses all over the United States, Puerto Rico and Guam and produces over 70% of commissioned soldiers in the United States army. [5] The programs are designed to turn college students into Army Officers; the ROTC cadets are subjected to mandatory physical training (PT) at least three times a week. [5] The cadets work on both muscular and cardiorespiratory endurance in order to pass the Army Physical Fitness Test (APFT). [6] The APFT is given on a bi-annual basis to ensure cadets maintain proper physical fitness during the course of the calendar year. [6] However, the ROTC programs abide by the university's academic calendar, in which the summer break warrants an 18-week cessation in the ROTC cadet's physical training. Lengthy periods of training cessation have been shown to decrease physical performance [2, 3, 5, 20] and cardiorespiratory endurance. [1, 8-14] Conversely, body composition measurements have been shown to increase during periods of training cessation. [8, 9, 11] Previous authors have determined the effect of < 6-weeks cessation in cardiorespiratory endurance and body composition measurements in trained athletes however limited literature exists on cessation in training lasting greater than three months in athletes. [1, 14] The cardiorespiratory effects of detraining in the ROTC cadets has been studied before [1], however there is a dearth of research that has examined the effect of cessation in training on body composition and cardiorespiratory performance in ROTC cadets.

Army ROTC Physical Fitness Standards

Army Soldiers are a non-traditional type of athlete that are exposed to a multitude of different issues that most traditional athletes have never been exposed. The Army ROTC cadets, however, are very similar to college athletes because they complete physically exhausting routines similar to those as college athletes. The ROTC cadets have to meet strict criteria to maintain in peak physical condition in order to be fit for active military combat and to successfully complete the APFT.

A study by Sharp et al. [3] compared the physical fitness levels of recruits entering the United States Army in 1998 to those who entered in 1978 and 1983. In 1998, 182 men and 168 women (n=350) completed skinfold estimations of percent body fat (%BF), maximum oxygen consumption (VO_{2max}), upper-body (UB), lower-body (LB), and upright pulling (UP) isometric strength tests before beginning basic training at Fort Jackson, SC. Comparisons were made to basic trainees at Fort Jackson in 1978 (skinfolds, VO_{2max}, UB, and LB) and 1983 (skinfolds and UP). The VO_{2max} results of men in 1998 were similar to recruits from 1978 (50.6 ± 6.2 $mL \cdot kg^{-1} \cdot min^{-1}$). The women recruits from 1998 showed a 6% increase in body weight from recruits tested in 1978. The 1998 recruits were stronger on all measures of muscle strength than recruits measured in 1978 (men- UB= 16%, LB=12%; women-UB=18%, LB =6%) and 1983 (men- UP= 7%; women- UP= 6%). The aerobic capacity, muscle strength, and FFM of 1998 recruits were comparable to or greater than that of 1978 and 1983 recruits.

Thomas et al. [5] evaluated a cadre of the ROTC cadets current fitness levels compared to APFT norms and the data of age-and sex-matched peers. Forty-three cadets (30 men and 13 women) performed the APFT, cardiovascular fitness test (VO_{2max}), underwater weighing and 1RM of bench press. The VO_{2max} was determined using a Bruce protocol to exhaustion on a treadmill. Mean standard deviations were calculated to provide the physical fitness profile for each parameter. Male cadets (21.0 ± 2.2 years) scored 49.6 ± 6.1 $ml \bullet kg^{-1} \bullet min^{-1}$ for VO_{2max}, 14.8 ± 4.2 %BF, 86.5 ± 24.9 kg for 1RM bench press, 13.97 ± 1.4 minutes on the 2-mile run, 70.5 ± 12.8 sit- ups, and 60.2 ± 13.2 push-ups. The female cadets (20 ± 2.4 years) scored 40.8 ± 3.9

ml•kg^{-1}•min^{-1} for VO_{2max}, 23.9 ± 3.8 % body fat, 35.3 ± 8.2 kg 1RM bench press, 2-mile run of 17.0 ± 1.6 minutes, 65.0 ± 12.9 sit- ups, and 33.3 ± 11.2 push-ups. The mean scores for both genders were above the 83rd percentile on all APFT tests. Male and female %BF scores were ranked average when compared to peer-age and sex corrected norms. The ROTC cadets exhibited average to above average levels of fitness with the exception of the women's bench press values. This study shows that the PT program the cadets complete in order to train for the APFT is effective in preparing the cadets for the rigors of the military.

Crawford et al. [2] compared physical and physiological fitness test performance between soldiers meeting the Department of Defense (DOD) body fat standard (≤18%) and those exceeding the standard (≥18%). Ninety-nine (n=99) male subjects from the Army 101st Airborne Division participated in the study and were split into two groups. Group 1 consisted of subjects that were ≤ 18% and group 2 consisted of subjects that were ≥18%. Anaerobic power (AP), aerobic capacity, and the APFT were conducted. Results indicated that subjects in group 1(≤18% BF) who met the DOD body fat goal performed significantly better than those in group 2 (>18 %BF) on 7 of the 10 physical and physiological tests performed. Group 1 (≤18 %BF) had significantly higher values for AP (8.3W/kg and 7.2 W/kg) and VO_{2max} (52.2 ml•kg^{-1}•min^{-1} and 44.1 ml•kg^{-1}•min^{-1}) than group 2 (≥18%), respectively ($p \leq 0.001$). The 3 APFT values showed that only push-ups were significantly different between group 1 scoring and group 2 (78.2 and 65.7 push-ups) respectively. There was no significant difference in the sit-up and timed run between the two groups. Results from this study suggest that in soldiers who met the DOD standards for %BF performed better on tests of anaerobic power, aerobic capacity, and push-ups. Authors concluded that higher %BF would comprise physical and physiological performance in army soldiers.

Froelicher et al. [22] completed a study to determine which VO_{2max} test was more valid in predicating someone's actual VO_{2max} from maximal treadmill time. The two different tests examined in this study were the Balke and Bruce protocol. 156 subjects participated in the study. Seventy-nine air crewmen completed the Balke protocol while seventy-seven were tested under the Bruce protocol. A sedentary group or exercise group was made depending on the subject's previous month activity level (Sedentary n=34, Exercise n=45). The groups were brought in at different times and completed the test. The Balke protocol was completed in the morning while the Bruce was completed in the afternoon; all subjects fasted for at least 5 hours prior testing. Mean VO_{2max} values underwent analysis in order to determine the differences between different groups and variables. Groups showed a significant difference in VO_{2max} values followed by the Bruce protocol (sedentary- 36.3 ± 5.3 $ml \cdot kg^{-1} \cdot min^{-1}$; exercise-47.8 ± 9.0 $ml \cdot kg^{-1} \cdot min^{-1}$). The results of the study showed that there were no statically differences between the two different protocols; they are both clinically acceptable protocols.

ROTC cadets must be able to demonstrate the proper strength and cardiorespiratory endurance capable of active duty. The literature states that the ROTC cadets that complete the APTF have shown differences in cadets that are have more %BF than those whom do not have as much. [2] Studies also show that the APFT is helpful in testing muscle endurance and cardiorespiratory endurance over the course of PT.[5] Lastly, studies have shown that soldiers are becoming less fit by having higher body mass and %BF than those in years past. It is vital to make sure that the solider are being properly trained in order for them to be deployed for active military duty.

Body Composition

Koundourkis et al. [11] tested 55 male professional soccer players from two different Greek league teams (Team A- n=23; 25.5 ± 5.3 years, Team B- n=22; 24.7 ± 4.9 years) to examine the effects of a six-week off-season detraining period on exercise performance and body composition. The pre-test collection was done following the season in May. Anthropometrics including height and weight were collected, %BF was the determined by using skinfold using the four-site formula. After a six-week detraining period, body mass had significantly increased in team A and team B (77.60 ± 5.88 kg vs. 79.13 ± 6.16 kg; $p \leq 0.001$; 77.89 ± 8.75 kg vs. 79.49 ± 8.95 kg; $p \leq 0.001$, respectfully) following the detraining session. Percent Body fat showed similar increased on both teams A (9.2 ± 3.33% vs. 11.01 ± 4.11%; $p \leq 0.001$) and B (9.43 ± 3.55% vs. 10.40 ± 4.08%; $p \leq 0.001$). The author concluded that the six-week cessation in training contributed to the gain in overall body mass and %BF.

Sharp et al. [3] estimated %BF by the use of a four-site skin-fold techniques on 350 United States Army recruits in 1998 to compare data from skin-fold assessments from 1983 and 1978 Army recruits. Subjects were tested at the biceps, triceps, subscapular, and suprailliac by a clinician using Harpenden Calipers (Country Technology, Inc., Gays Mills, WI). Height (centimeters) was recorded using a stadiometer (Model GPM, Seritex, Inc., Carlstadt, NJ). Body weight (kilograms) was measured using a digital scale (Model 770, Seca Corp., Columbia, MD). Body weight (BW) of 1998 recruits was greater than 1978 recruits (men-12% and women-6%) and 1983 recruits (men-8% and women-7%). The %BF of 1998 recruits was greater than 1978 recruits (men-15% and women-5%) and 1983 recruits (men-15% and women- 17%). The 1998 men had more fat-free mass (FFM) than men in 1978 (8%) or 1983 (5%), whereas 1998 women only different from those measured in 1978. The authors concluded that the recruits were coming into the army more overweight than in years past.

Tran and Weltman et al. [23] designed a study to create a generalized equation for predicting body density of women from girth measurements. 482 white female subjects (17-79 years) who ranged in height, weight and age were tested for body density, residual volume and girth measurements. Height and weight were taken by the use of a stadiometer and digital scale. In order to test body density the subjects were hydrostatically weighed. Underwater weight was assessed at residual volume for at least 10 trials and residual volume was measured using an oxygen diluting technique. Circumference girth measurements were recorded from five different sites; the abdomen was collected laterally midway between lowest portion of the rib cage and iliac crest and anteriorly midway between the xiphoid process of the sternum and the umbilicus. The abdomen recording was measured laterally at the level of the iliac crest and anteriorly at the level of the umbilicus. The Iliac measurement was collected anteriorly at the anterior superior iliac spine. The Hips (buttocks) measurement was collected anteriorly at the level of the symphysis pubis and posteriorly at the maximal protrusion of the gluteal muscles. Lastly, the thigh measurement was collected just below the gluteal flow or maximum thigh circumference. The use of five girth measurements, height, and age enable us to develop regression equations to predict body density in women that are comparable in accuracy to those using just skinfold caliper. The use of five girth measures, body weight, height and age, applied to a sample of women with large ranges in age and body composition resulted in a generalized equation for predicting body density that is comparable in accuracy to previously published equations using skinfold thickness.

Similarly, Jackson and Pollock [15, 16] wanted to derive generalized regression equations that would provide body density (BD) estimates for women varying in age and body composition. 331 adult women (18-55 years) were measured for standing height, weight and skinfold tested. Skinfold sites were measured on the right side at the chest, axilla, triceps, subscapula, abdomen, suprailium and thigh using a Lange skinfold caliper. Subjects were instructed not to eat six-hours previous to the collection and also not having smoked within three hours of testing. Hydrostatic weighting method to determine body density was preformed on a Chatillon 15-kilogram (kg) scale. Body density was calculated from the formula of Brozek et al and fat percentage calculated from Siri et al formula. A multiple regression analysis was used to make generalized equations. Valid generalized body composition equations could be derived for women varying in body composition and age.

The goal for determining an individual's %BF is to make sure that accurate data is collected in order to obtain proper values. Gender plays a major role determining the methods in which %BF values are collected. Methods of skinfold and circumference measurements have been combined to show the best evaluation of the %BF [15, 16, 23].

Cardiorespiratory Endurance

The principle of training reversibility (detraining) states that whereas regular physical training results in several physiological adaptations that enhance athletic performance, stopping or markedly reducing training induces a partial or complete reversal of these adaptations, compromising athletic performance. [12] Multiple studies have examined the factors which contribute to the degree of cardiorespiratory detraining and have determined that time-duration and training levels affect the body differently. [12, 14] Previous literature by Mujika et al. has shown significant cardiorespiratory changes in both short-term (<4 weeks) and long-term (>4 weeks) periods of training cessation. [12, 14] During a short-term cessation in cardiorespiratory fitness, research has found there to be a decline in maximal oxygen uptake (VO_{2max}) in highly trained individuals between 4-14%. [12] In lesser or recently trained (4-8 week) athletes there has shown to be a decrease of 3.6-6%. [12] However, during periods of detraining lasting >4weeks, highly trained individuals have shown declines in VO_{2max} of 5-20%. [1, 4, 8-11, 14] Maximal oxygen uptake progressively declines during the initial 8-weeks but then stabilizes to levels higher or equal to sedentary control individuals. [14] Furthermore, it has been determined that the higher the trained-state VO_{2max} the larger the decline.[12] Also, another key factor to the degree of physiological loss present over the period of detraining is the amount of exercise completed during at the period of cessation.

Garcia-Pallares et al. [10] analyzed the effects of a 5-week post-season detraining period on physiologic and performance parameters of 14 elite male kayakers (25.2 ± 2.5 years). Baseline concentration of blood lactate, VO_{2max}, paddling speed at VO_{2max}, stroke rate at VO_{2max}, and paddling power at VO_{2max} as determined via an incremental exercise test on a kayak ergometer, was measured at the end of a 47-week season. Subjects were placed in one of two groups: a reduced training (RT) group (n=7) or a complete-cessation training (CT) group (n=7). The RT group performed one-resistance and two-endurance training sessions per week. Five weeks after baseline testing, subjects underwent the second testing session. Maximal oxygen consumption decreased 11.3% ($p < 0.01$) and 5.6% ($p < 0.05$) in the CT and RT groups, respectively. Paddling speed significantly decreased 3.3% and stroke rate showed a significant increase of 5.2% ($p < 0.05$) in the TC group. Paddling power showed significant decrease (7.9% and 3.9%, $p < 0.05$) in both CT and RT respectively. The authors recommend that athletes preform one resistance and two endurance-training sessions per week at moderate intensity in order to decrease adverse detraining effects.

Similarly, Ormsbee et al. [9] also examined the effects of a 5-week (35-42 days) detraining period on body composition, aerobic fitness, resting metabolism, mood state, and blood lipids, but in young collegiate swimmers (19.5 ± 1.0 years). Eight (n= 4 male, n= 4 female) subjects were measured two times. Baseline measurements, referred to as habitually trained (TR) test time, were obtained approximately 48-hours after a typical exercise bout during the week before end-of-season championships. A second, post-season test session was completed after 35–42 days of detraining (DT). All measurements were made over two consecutive days. Results indicated a significant increase in body weight at DT most attributable to a 12% increase in fat mass. No significant differences were found in body circumferences over time. A comparison of VO_{2peak} values from TR to DT revealed a significant decrease (46.7 ± 10.8 to 43.1 ± 10.3 $ml{\bullet}kg^{-1}{\bullet}min^{-1}$). Total time to exhaustion (TTE) was significantly lower in DT (11.1 ± 2.3 vs.12.2 ± 2.7 min.) when compared to TR values. The authors concluded that a short-term detraining period immediately following a competitive collegiate swim season adversely affected body composition and cardiovascular fitness.

Another study examined short-term detraining effects on Greek soccer players. Koundourkis et al. [11] tested 55 male Greek professional soccer players from two different teams. Team A (n=23; 25.5 ± 5.3 yrs.) and Team B (n=22; 24.7 ± 4.9 years) were examined in order to determine the effects of a six-week off-season detraining period on exercise performance and body composition. Maximum oxygen consumption was assessed using a motorized treadmill test to voluntary exhaustion following the soccer season. Paired t-tests were used to determine the measured parameters from the pre- and post-detraining period values.

Body weight showed significant increases in team A (pre-77.60 kg ± 5.88 vs. post- 79.13 kg ± 6.16; $p<0.001$), and team B (pre- 77.89kg ± 8.75 vs. post-79.49kg ± 8.95; $p<0.001$) following the 6-week detraining period. Percent body fat showed similar increases in both teams, team A (pre-9.2% ± 3.33 vs. post-11.01% ± 4.11; $p \leq 0.001$) and team B (pre-9.43% ± 3.55 vs. post-10.40% ± 4.08; $p \leq 0.001$). Mean VO_{2max} values decreased significantly from baseline values in team A (60.31 ± 2.52 $ml \cdot kg^{-1} \cdot min^{-1}$) when compared to values gathered after a 6-week detraining period (57.67 ± 2.54 $ml \cdot kg^{-1} \cdot min^{-1}$; $p< 0.001$). Team B also showed significant declines from baseline values (60.47 ± 4.13 $ml \cdot kg^{-1} \cdot min^{-1}$) to values obtained following the 6-week detraining period (58.30 ± 3.88 $ml \cdot kg^{-1} \cdot min^{-1}$; $p< 0.001$). Koundourakis et al. reported significant declines in aerobic performance adaptations and negative effects on body composition at the conclusion of a 6-week detraining period in professional male soccer players.

Similarly, Kovacs et al. [8] examined physiological changes that occurred over a 5-week period in training cessation in eight (n=8) collegiate tennis players. Baseline values for anaerobic power (Wingate test), cardiorespiratory endurance (VO_{2max}) and muscular endurance (1 minute push-up and sit-up test) were taken prior to the 5-week training cessation. Paired t-tests were used to determine differences in pre- and post-break values. Anaerobic power showed a significant difference from baseline values (8.35 w/kg) when compared to post 5-week values (7.80 w/kg, $p< 0.05$). Maximum oxygen consumption showed significant decreases from baseline values (53.90 $ml \cdot kg^{-1} \cdot min^{-1}$), when comparing results collected after the 5-week training interruption (47.86 $ml \cdot kg^{-1} \cdot min^{-1}$, $p<0.05$). No significant differences were determined from the 1-minute push-up and sit-up tests. The authors concluded that a 5-week interruption of normal training can result in a decrease in anaerobic power and aerobic capacity.

Moderate length detraining research has been done by Liguori et al.[1] who examined cardiovascular endurance (VO_{2max}) changes over a 13-week detraining period in ROTC cadets. Thirty-two (male=24, female=8) cadets (21.1 ± 2.9 years) were baseline tested for VO_{2max}, body mass and waist circumference. The Modified Taylor treadmill test was used to determine VO_{2max} (ml/kg/min). A 2 x 2 ANVOA with an alpha was set at $p \leq 0.05$ revealed significant decreases in VO_{2max} values in male subjects (53.34 to 51.07 $ml \cdot kg^{-1} \cdot min^{-1}$) and female subjects (48.64 to 45.20 $ml \cdot kg^{-1} \cdot min^{-1}$; $p = .001$). The author concluded VO_{2max} values significantly declined in male (4.3%) and female (7.1%) ROTC recruits over a 3-month detraining period. Suggesting that a reduced training load should be implemented during the summer months in order to maintain strength and endurance gains.

A related study by Fatouros et al. [24] determined the effects of %BF, strength and anaerobic power after subjects were assigned to a 24-week high intensity or low intensity training program followed by a 48-week detraining period. Fifty-two inactive older males (71.2 ± 4.1 years) subjects were randomly assigned to one of three groups: control (C; n= 14), a low intensity strength training (LIST; n= 18) and high intensity strength training (HIST; n = 20). A baseline measurement for %BF was completed and the modified Bruce treadmill protocol was used to determine baseline VO_{2max} values. Baseline anaerobic power (AP) was measured using the Wingate anaerobic cycle test. One-repetition max (1RM) measurements of leg and chest press were taken at baseline, after the training period and following the detraining period. Subjects performed 14–16 maximal repetitions/set (50–55% 1RM) in the LIST protocol, and six to eight maximal repetitions/set (80–85% 1RM) in the HIST protocol 3-days a week. A repeated measures multivariate analysis of variance was performed on each dependent variable. Results showed HIST elicited greater gains in strength (63–91%), anaerobic power (17–25%) and mobility (9-14%; $p \leq 0.05$) respectively. All training induced gains in the LIST group had been stopped after four to eight months of detraining, whereas in the HIST group strength and mobility gains were maintained throughout detraining. Anaerobic power had returned to baseline levels after four months of detraining in both groups. Body weight and sum of skinfolds had decreased in the LIST group (1.9% to 1.6%) and HIST group (3.4% to 2.6%) after training. These changes were maintained for four months in the LIST group and for eight months in the HIST group during detraining. Fatouros et al. concluded that not only does the HIST protocol induce greater gains in strength, anaerobic power and whole body physical function of older men, but the body maintains the gains for longer periods.

Lo et al. [13] investigated changes in body composition, body size, muscle strength, and cardiorespiratory fitness (VO_{2max}) after 24-weeks of resistance or endurance training and detraining in 30 college-aged men. Thirty sedentary male students (20.4 ± 1.36 years; n=30) were randomly separated into a control group (CG=10), endurance-training group (ETG=10) or resistance-training group (RTG=10). Body fat percentages, body circumferences, VO_{2max} and strength test (1RM) were measured at three different points, at baseline, after 24-weeks of training, and after a 24-week detraining period to obtain values for each group. A 1-way MANOVA was used to test the differences in values over the three data collection periods. Results indicated significant increases in ETG (17%) and RTG (12%) from training to detraining sessions over the control group. RTG improved significantly (32%) more in upper body strength (UBS) than in the ETG (6%) and in the CG (6%) after training. No significant differences in waist, hip and thigh circumferences were reported. Therefore, the ETG and RTG performed significantly better than the CG in comparison to the baseline VO_{2max} values.

Within the literature, periods of detraining result in declines in both anaerobic power and aerobic endurance. The effects of short-term [1, 8-12, 20] and long-term [1, 8-11, 14] cardiorespiratory cessation periods have shown to elicit different effects over time. Anaerobic power performances have also shown to have different effects on muscular power over the course of a period of detraining.[13, 24-27] The detraining literature is clear that cardiorespiratory performances decrease over the course of both short and long-term detraining, however limited research exists on an ROTC population. Based on the literature, during periods of training cessations, Army Officers, Athletic trainers and decommissioned officers should supply cadets with structured workouts in order to maintain physical fitness during any detraining period to endure cadets continue to meet stringent physical standards that the ROTC maintain.

APPENDIX A: RESEARCH PARTICIPANT INFORMED CONSENT

Department of Kinesiology and Rehabilitation Science, University of Hawai'i at Mānoa
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Phone: 808-956-7606

I. Investigator

Principal Investigators: Ronald Hetzler, PhD, MS, Christopher Stickley, PhD, MS, ATC, CSCS; Kaori Tamura, PhD. Rebecca Romine, PhD, ATC; Ryan Kunkle, ATC.

II. Title

The Effect of an 18-week Detraining Period on Body Composition and Cardiorespiratory Endurance in a Cohort of ROTC Cadets.

III. Informed Consent

You are being asked to participate in a study conducted through the University of Hawai'i at Mānoa. The purpose of this consent form is to provide you with all the information pertaining to this study, and help you decide if you would like to become a subject in research. This study is part of a major project required for a master's student to obtain his/her master's degree. This form may contain words that you do not understand. If there are any words that you do not understand or that you want to clarify, please ask the research staff to explain them. Please take your time to review this consent form and do not hesitate to voice any concerns you may have with the research staff. If you agree to take part in this study, it is required you sign this consent form. It is important that you understand that taking part in this study is of your own free will. You may decide not to participate, or you may decide to stop being in the study at any time, and it will not affect your regular medical care now or in the future.

IV. Why is this Study Being Done

You are being asked to take part in this study because you are between 18-35 years of age, and part of the University of Hawaii's Reserve Officer Training Corps (ROTC) program. A total of 100 subjects will take part in this study.

The purpose of this study is to determine the effect of the University of Hawaii's Army ROTC physical training program on physical fitness components including: (1) maximal oxygen consumption, 2) cardiorespiratory and muscular endurance, and 3) body composition. A secondary purpose is to investigate the relationship of these physical fitness assessments to both before and after a 3-month training cession.

V. Study Procedures

If you take part in this study, you will be asked to report to the Human Performance Lab at the University of Hawaii. You will complete a total of 2-separate test sessions. The first test session will be prior to the conclusion of the Army ROTC physical training program, and the second test session will after returning for the following semester of the

Army ROTC physical training program. Each test session will last approximately an hour and a half. You will be asked to bring a comfortable shirt and t-shirt for the testing session; you will be asked to refrain from eating, drinking caffeine, and drinking alcohol three hours prior to testing; you will be asked to refrain from exercise for at least 24-hour prior to each test session; and you will be asked to stay hydrated 24-hours prior to testing. At the beginning of the test session, you will be asked to complete a confidential medical health history questionnaire form, a physical activity readiness questionnaire, and the George questionnaire.

If you take part in this study, you will have the following tests and procedures:

Resting heart rate and resting blood pressure: After sitting comfortably for five minutes, your resting heart rate and resting blood pressure will be measured. Resting heart rate will be assessed via palpation of the radial artery for 30-seconds. Resting blood pressure will be assessed with a stethoscope and blood pressure cuff. The blood pressure cuff will be wrapped around your dominant arm, and blood pressure will then be assessed two times, with a 2-minute rest in between.

Anthropometric Measures: Height and body mass will be measured and recorded with your shoes off.

Body Composition Measurements: You will be asked to remove your shirt so that the testers can access certain measurement sites. A researcher will use a tape measure to identify specific anatomical landmarks on the right side your body that will be used for the skinfold thickness measurement site. These spots will be marked with a marker so that researchers use the same exact site for each measurement. The marker will be removed after testing is complete via an alcohol prep pad.

Body composition assessment includes Jackson and Pollock's 3-site skinfold thickness measurements and body circumference measurements, which differ based on gender. The three skinfold thickness sites will be measured with Lange skinfold calipers on the chest, abdomen, and thigh (males) and on the triceps, supra-ilium, and thigh (females). Body circumference measurements will be assessed be using a standardized tape measure. The circumference measurements for males include the neck, abdomen, and umbilicus; the female circumference measurements include the neck, abdomen, umbilicus and hip. Knee breadth and bi-iliac breadths will also be measured on male subjects with a sliding anthropometer.

Blood Lactate Concentration Test: Prior to the start of testing, baseline blood lactate concentrations will be obtained via the finger-prick method. Seven minutes after completion of a graded treadmill test (GXT), a second blood lactate concentration measurement will be obtained.

Maximal Oxygen Consumption Test: You will complete a VO_2max test on a treadmill according to the Astrand Protocol. Maximal oxygen consumption is the clinical gold standard for assessment of cardiorespiratory endurance. The Astrand Treadmill Protocol is a multi-stage treadmill test in which the incline (grade) of the treadmill is increased every 2 minutes. You will warm up prior to test administration, and be fitted with a HR monitor over your chest to collect HR values for the duration of the GXT. Stage one of the treadmill protocol will begin with a self-selected speed, and a grade of 0%. A 2.5% increase in grade will occur following each stage completion of the GXT. Researchers will ask you how hard the work feels for you at the end of each stage based on a 6-20 point Borg's ratings of perceived exertion (RPE) scale. The exercise test will be terminated when you indicate that you cannot go any further by fully grasping the handrails of the treadmill.

The researchers may decide to remove you from the study if you:

1. Are determined unfit to participate by the American College of Sports Medicine (ACSM) standards
2. Cannot perform or complete the exercise test
3. Become injured during the test

VI. Risks

When taking blood lactate concentrations, a small needle will be used to prick your finger to obtain a droplet of blood. The finger prick will cause slight bleeding, but should be minimally painful. Risks associated with caliper use include a mild pinching sensation and slight pain due to the pinching of the skin, and the clamping of the caliper. While participating in this study, there are exists the possibility of certain changes occurring during the test. These include abnormal blood pressure, fainting, irregular, fast or slow heart rhythm, and in rare instances, heart attack, stroke, or death. Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and by careful observations during testing. Emergency equipment and trained personnel are available to deal with unusual situations that may arise.

VII. Benefits

You may not receive direct/immediate benefits. Upon request, you can receive information pertaining to your physical fitness levels and body composition (%BF, height, weight, etc). Results of this study may help the Army assess the cadet's body composition, muscular and cardiorespiratory endurance when returning from a three-month non-mandatory training cessation in physical training. Sport and strength coaches may be able to use this information in order to maintain or minimize their athletes' level of fitness over periods of training cessations.

VIII. Costs

You will not be held liable for any costs regarding this study. All equipment and testing procedures will be of no cost to you.

IX. Compensation

You will not receive any compensation for participating in this study.

X. Confidentiality

All research information about you will be held confidential to the extent allowed by state and federal law. Your personal information will not be given to anyone without your written permission. A code, which will be known only to research personnel, will be used instead of your name on any records pertaining to this study. Research records which may be identifiable to you will be kept in a secure locked file in the Department of Kinesiology and Rehabilitation Science at the University of Hawai'i at Mānoa when not being used. These materials will be permanently disposed of (destroyed) in a period no longer than 5 years.

Information gathered in this research study may be published or presented in public forums, however your name and other identifying information will not be used or revealed. However, agencies with research oversight, such as The University of Hawaii Committee on Human Studies, have the right to review research records. Confidentiality does not prevent you from releasing information about yourself and your participation in the study. You will be asked to sign an authorization form to release personal health information.

XI. Voluntary Participation

Your decision to take part in this study is voluntary. You may refuse to participate or you may withdraw from the study at any time. Your decision to participate or to withdraw from the study will not affect your medical care provided by the primary ROTC athletic trainer at morning Physical Training sessions.

XII. Injury Related to the Study

If you are injured as a result of being in this study, immediate treatment is available for your injuries. You will then be told where you may get other treatment. The cost for this treatment will be charged to your insurance company or to you. Your insurance company may not pay for these costs. If your insurance will not pay for these costs, they will be your responsibility. The University of Hawaii has no program to pay you or compensate you in any way for your injuries.

XIII. Questions

You are free to ask questions that you may have about your treatment and your rights as a research participant at any time. If you have any questions related to this study, please contact any of the principal investigators: Rebecca Romine, PhD, ATC at (808) 349-8193, or Ryan Kunkle, ATC, at (610) 349-1477. If you have questions about your rights as a research subject, contact the UH Committee on Human Studies at (808) 956-5007.

XIV. Statement of Consent

I have read the above information, or it has been read to me. I have had the opportunity to discuss this research study with Rebecca Romine and/or her study staff, and I have had my questions answered by them in language I understand. I take part in this study of my own free will, and I understand that I may withdraw from participation at any time and this will not affect my medical care. My consent to participate in this study does not take away any of my legal rights in the event of negligence or carelessness of anyone working on this project. A copy of this consent form has been given to me.

I agree to take part in this study.

Print Name	**Signature**	**Date**

Witness:

Print Name	**Signature**	**Date**

APPENDIX B: HEALTH/INJURY HISTORY QUESTIONNAIRE

Instructions: ***Please complete each question to the best of your knowledge/ability. Please ask the investigators if you have any questions.***

Part 1. Participant Information

Date of Birth:________________ Age (years) _________ Sex: M / F

Home Address:___________________________________

City/State/Zip:______________________________ Email: ______________________

Home/Cell Phone (__) __________________ Emergency Phone (___) _____________

Emergency Contact Person/Relationship: _____________________________________

Part 2. Medical History: the subsequent sections were obtained following guidelines for exercise testing (American College of Sports Medicine, 2005).

A. History: please check the box any condition you currently have or had in the past.

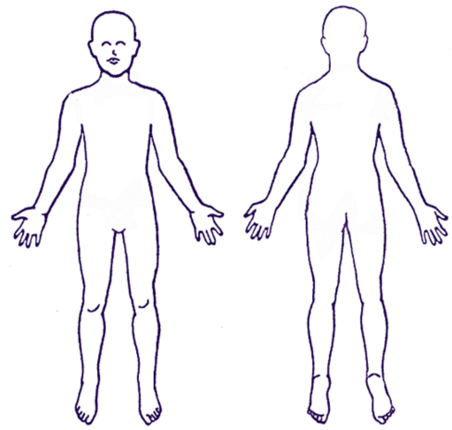
- ☐ Heart Attack
- ☐ Heart Surgery
- ☐ Cardiac Catheterization
- ☐ Coronary Angioplasty (PTCA)
- ☐ Pacemaker/implantable cardiac
- ☐ Defibrillator/rhythm disturbance
- ☐ Heart valve disease
- ☐ Heart failure
- ☐ Heart transplantation
- ☐ Congenital heart disease
- ☐ Diabetes
- ☐ Asthma
- ☐ Lung Disease
- ☐ Heart murmur
- ☐ Seizures
- ☐ Head injury or concussion
- ☐ Loss of consciousness or memory

B. Symptoms: please check the box for any symptoms you have or had experienced at rest, during or following exercise.

- ☐ Chest discomfort
- ☐ Cough or wheezing
- ☐ Dizziness, fainting, or blackouts
- ☐ Difficulty breathing

☐ Abnormal heart beats

Musculoskeletal Symptoms: please check the box for any symptoms you have or had experienced, locate and label the occurrence of each symptom on the figure below.



☐ Numbness
☐ Tingling
☐ Pain
☐ Swelling
☐ Burning
☐ Cramping

Cardiovascular Health: please check the box for any conditions applicable to you.

☐ Male over age 45 years
☐ Female over age 55 years
☐ Smoke or smoking cessation within the previous 6 months
☐ High blood pressure (greater than 140/90 mm Hg)
☐ Currently taking blood pressure medication
☐ High cholesterol (greater than 200 mg/dL)
☐ Family history of heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister)
☐ Physically inactive (less than 30 minutes of physical activity at least 3 days per week).
☐ Overweight

Explain all “Yes” answers here and any checked boxes:

____
____
____

Signature of Participant: ____________________________ Date: _______________

Signature of Researcher/: ____________________________ Date: _______________

APPENDIX C: PHYSICAL ACTIVITY QUESTIONNAIRE FORM

Name: ________________________________ Date: _____________________________

Telephone: ____________________________

Date of Birth:_______ Age: _________ Height: _____________ Weight:________

In Case of Emergency Contact: ___________________________ Relationship:___________

Address: ___________________________ Phone: _______

Physician: ___________________________ Specialty: _______

Address: _______ Phone: _______

Are you currently under a doctor's care: Yes ☐ No ☐

If yes, explain: ___________________________

When was the last time you had a physical examination? ___________________________

Have you ever had an exercise stress test: Yes ☐ No ☐ Don't Know ☐

If yes, were the results: Normal ☐ Abnormal ☐

Do you take any medications on a regular basis? Yes ☐ No ☐

If yes, please list medications and reasons for taking: ___________________________

Have you been recently hospitalized? Yes ☐ No ☐

If yes, explain: ___________________________

Do you smoke? Yes ☐ No ☐

Are you pregnant? Yes ☐ No ☐

Do you drink alcohol more than three times/week? Yes ☐ No ☐

Is your stress level high? Yes ☐ No ☐

Are you moderately active on most days of the week? Yes ☐ No ☐

Do you have:

High blood pressure? Yes ☐ No ☐

High cholesterol? Yes ☐ No ☐

Diabetes? Yes ☐ No ☐

Have parents or siblings who, prior to age 55 had: Yes ☐ No ☐

A heart attack? Yes ☐ No ☐

A stroke? Yes ☐ No ☐

High blood pressure? Yes ☐ No ☐

High cholesterol? Yes ☐ No ☐

Known heart disease?	Yes ☐	No ☐
Rheumatic heart disease?	Yes ☐	No ☐
A heart murmur?	Yes ☐	No ☐
Chest pain with exertion?	Yes ☐	No ☐
Irregular heart beat or palpitations?	Yes ☐	No ☐
Lightheadedness or do you faint?	Yes ☐	No ☐
Unusual shortness of breath?	Yes ☐	No ☐
Cramping pains in legs or feet?	Yes ☐	No ☐
Emphysema?	Yes ☐	No ☐
Other metabolic disorders (thyroid, kidney, etc.)?	Yes ☐	No ☐
Epilepsy?	Yes ☐	No ☐
Asthma?	Yes ☐	No ☐
Back pain: upper, middle, lower?	Yes ☐	No ☐
Other joint pain (explain on back of form)?	Yes ☐	No ☐
Muscle pain or an injury (explain on back of Form)?	Yes ☐	No ☐

To the best of my knowledge, the above information is true.

Signature ______________________________

Date______________________________ Witness ______________________________

APPENDIX D: PHYSICAL FITNESS QUESTIONNAIRE

Adapted from (George et al, 1997)

This survey contains three questions. You will be asked to predict your overall level of physical activity and to predict how well you can cover a distance of one and three miles. Please circle one answer that best describes your abilities.

1. Suppose you were going to exercise continuously on an indoor track for 1 mile. Which exercise pace is just right for you- <u>not to easy</u> and <u>not too hard</u>? Circle the appropriate number (any number, 1 to 13)

   1. Walking at a *slow* pace (18 minutes per mile or more)
   2. Walking between *slow* and *medium* pace
   3. Walking at a *medium* pace (16 minutes per mile)
   4. Walking between *medium* and *fast* pace
   5. Walking at a *fast* pace (14 minutes per mile)
   6. Pace between walking *fast* and jogging *slow*
   7. Jogging at a *slow* pace (12 minutes per mile)
   8. Jogging between *slow* and *medium* pace
   9. Jogging at a *medium* pace (10 minutes per mile)
   10. Jogging between *medium* and *fast* pace
   11. Jogging at a *fast* pace (8 minutes per mile)
   12. Pace between jogging *fast* and running fast
   13. Running at a *fast* pace (7 minutes per mile or less)

2. How fast could you cover a distance of 3-miles and NOT become breathless or overly fatigued? Be Realistic.
Circle the appropriate number (any number, 1 to 13)

   1. I could walk the entire distance at a *slow* pace (18 minutes per mile or more)
   2. I could walk the entire distance between *slow* and *medium* pace
   3. I could walk the entire distance at a *medium* pace (16 minutes per mile)
   4. I could walk the entire distance between *medium* and *fast* pace
   5. I could walk the entire distance at a *fast* pace (14 minutes per mile)
   6. I could complete the entire distance between walking *fast* and jogging *slow*
   7. I could jog the entire distance at a *slow* pace (12 minutes per mile)
   8. I could jog the entire distance between *slow* and *medium* pace
   9. I could jog the entire distance at a *medium* pace (10 minutes per mile)
   10. I could jog the entire distance between *medium* and *fast* pace
   11. I could jog the entire distance at a *fast* pace (8 minutes per mile)
   12. I could complete the entire distance between jogging *fast* and running *slow*
   13. I could run the entire distance at a *fast* pace (7 minutes per mile or less)

3. Circle the number that best describes your overall level of physical activity for the previous 6 MONTHS:

   1. I avoid walking or exertion; e.g., always use elevator, drive when possible instead of walking

2. **light activity:** I walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration

3. **moderate activity:** I participate in 10 to 60 minutes per week of moderate activity; such as golf, horseback riding, calisthenics, table tennis, bowling, weight lifting, yard work, cleaning house, walking for exercise

4. **moderate activity:** I participate in over 1 hour per week of moderate activity as described above

5. **vigorous activity:** I run less than 1 mile per week or spend less than 30 minutes per week in comparable activity such as running or jogging, lap swimming, cycling, rowing, aerobics, skipping rope, running in place, or engaging in vigorous aerobic-type activity such as soccer, basketball, tennis, racquetball, or handball

6. **vigorous activity:** I run 1 mile to less than 5 miles per week or spend 30 minutes to less than 60 minutes per week in comparable physical activity as described above

7. **vigorous activity:** I run 5 miles to less than 10 miles per week or spend 1 hour to less than 3 hours per week in comparable physical activity as described above

8. **vigorous activity:** I run 10 miles to less than 15 miles per week or spend 3 hours to less than 6 hours per week in comparable physical activity as described above

9. **vigorous activity:** I run 15 miles to less than 20 miles per week or spend 6 hours to less than 7 hours per week in comparable physical activity as described above

10. **vigorous activity:** I run 20 to 25 miles per week or spend 7 to 8 per week in comparable physical activity as described above
11. **vigorous activity:** I run over 25 miles per week or spend over 8 hours per week in comparable physical activity as described above

APPENDIX E: DATA COLLECTION FORM

Date:	Time:	Gender:
MS1, MS2, MS3, MS4 (Circle one)	Age:	DOB:
Testing Session: (Circle one) Spring Fall	Height: Cm: in:	Body mass: Kg: Lbs:
Summer assignment:	RHR:	Blood Pressure: T1: T2: AVG:

Male Skinfold:

	Test 1	**Test 2**	**Test 3**	**AVG**
Chest:				
Abdomen:				
Thigh:				

Female Skinfold:

	Test 1	**Test 2**	**Test 3**	**AVG**
Triceps:				
Suprailium:				
Thigh:				

Male Circumference:

	Test 1	Test 2	Test 3	AVG
Neck:				
Umbilicus:				

Female Circumference:

	Test 1	Test 2	Test 3	AVG
Neck:				
Waist:				
Hip:				

Iliac Crest Circumference:

	Test 1	Test 2	Test 3	AVG
Iliac Crest				

Modified Åstrand Treadmill Protocol

Cart Start (min): ____________

Minutes	Treadmill Stage	Cart End Stage Minutes:	Grade (%)	RPE	HR Cart (bpm)	HR Watch (bpm)	RER	VO_2	Completed
0-3 min	Stage 1		0						
3-5 min	Stage 2		2.5						
5-7 min	Stage 3		5.0						
7-9 min	Stage 4		7.5						
9-11 min	Stage 5		10.0						
11-13 min	Stage 6		12.5						
13-15 min	Stage 7		15.0						

Physiological Assessment

Treadmill Speed: (mph)	
Pre-Blood Lactate concentration: (Mmol)	

Post- Blood Lactate concentration: (Mmol)		
Final RPE:		
Heart Rate at Termination: (bpm)		
VO_2max: (ml/kg/min)		
METS:		
Final RER:		
Final time on treadmill: (Min)	**Cart:**	**Protocol**:

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